Non-Native Invasive Species on Forests and Rangelands

One of the oldest and potentially most serious forms of environmental disruption is the introduction of a non-native species. The magnitude of possible environmental change has not been recognized until recently. This is particularly true when considered against the more publicized effects of habitat alteration, toxics, and other environmental perturbations.

Spotted knapweed (Centaurea maculosa). Photo California Department of Food and Agriculture.

The strength of public response to non-native species issues is lessened by the widespread acceptance of exotic domestic species that serve a purpose to society. The growth of agriculture in California and elsewhere is based on the use of non-native species of grain, fruit, and livestock. These species, however, are generally dependent on intensive husbandry and are not successful competitors in the wild. They have been beneficial to the interests of society with minimal effect on native species outside of direct habitat loss. Due to these successes, people tend not to think of non-native species as harmful to humans or at worst one species is being traded for another (Courtenay, 1978).

Two principle changes have affected ecosystem function in California—an increase in the pool of non-native species due to global movement of people and a high level of land use change.

As described elsewhere in this Assessment, (see Overview of Biological Diversity and Ecosystem Management), ecologists increasingly recognize that ecosystems are dynamic in nature—that change is the predominant and common feature. Rates of change may vary with time and are expressed by differences in species densities and occurrence such that composition of any ecosystem is not static. Opportunities for invasive species to successfully establish themselves and expand their distribution are enhanced during periods of rapid ecosystem change.

Within the relatively short time frame Europeans have been in California, two principal changes have taken place to alter how ecosystems function. The first is a marked increase in the pool of potential invasive species brought about by the movement of people and transport of biota across global and regional barriers that traditionally separated species. The second is the high level of land use change undertaken in California to meet the requirements of a growing population. The level and types of disturbance experienced by many of California's ecosystems have been significant and far reaching and examples of human transformation of those systems abound (BioSystems Analysis, 1994). Each of these impacts is discussed in turn.

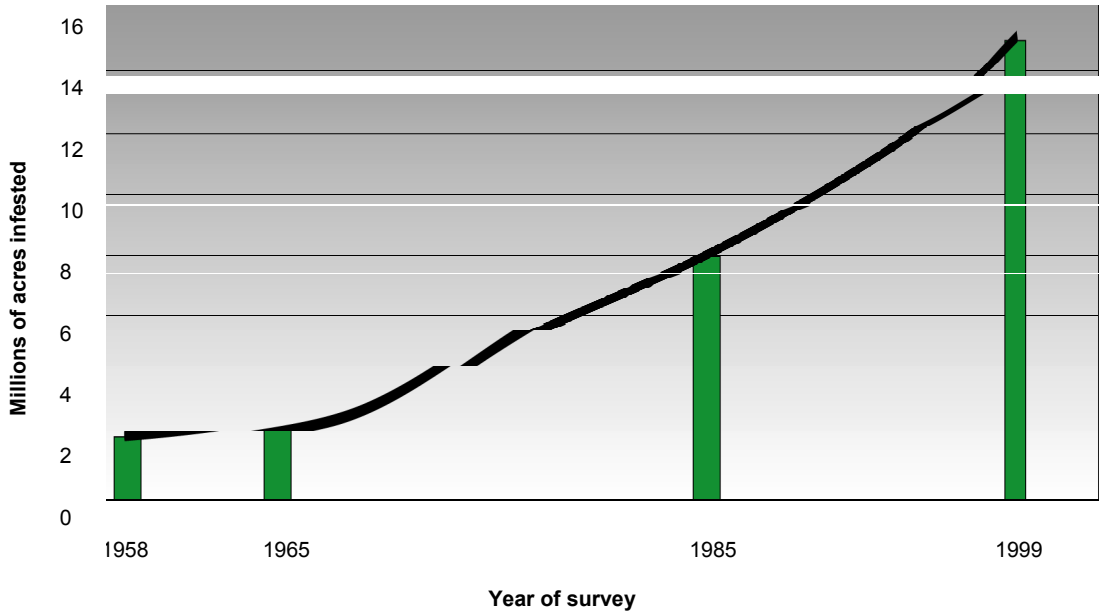
Findings on increased pool of invasive non-natives

Historically, the majority of non-native plants introduced to California first established themselves near settlements and centers of commerce. More recently, reports of new non-native species have not been so restricted as a variety of human activities and an efficient transportation system have introduced non-native species to all regions (see Non-native species in the Sierra Nevada Mountains, page 17). Large increases in the mobility of people and globalization of economies and trade in California over the last 100 years have markedly increased the rate of exchange and establishment of species between ecosystems.

Yellow starthistle (Centaurea solstitialis). Photo by Jo–Ann Ordano, California Academy of Sciences.

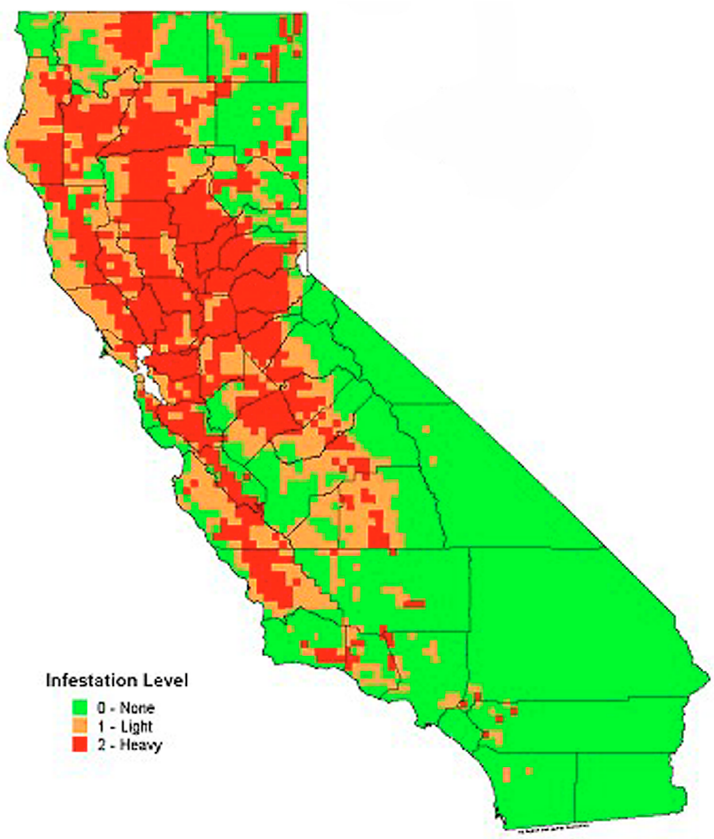
This increased scale of global trade and need to move products at increasing speed has also facilitated species interchange. Species now cross oceans with increasing frequency in the ballast water of ships, within containerized shipping, or by air. In some cases the rate of spread, once successfully established, has been exceptionally rapid. Three examples of rapidly spreading plant species are yellow starthistle (*Centaurea solstitialis*), cheat grass (*Bromus tectorum*), and scotch broom (*Cytisus scoparius*). Yellow starthistle has expanded its range in California from 1.2 million acres in the late 1950s to 15 million acres in 1999 (Figures 1 and 2) (Pitcairn et al., 1998; Maddox et al., 1996; Randall and Hoshovsky, 2000; DiTomaso, 2002) (see Yellow Starthistle).

Figure 1. Area of estimated expansion of yellow starthistle infestation in California from 1958 to 1999



Source: Maddox and Mayfield, 1985

Figure 2. Distribution of yellow starthistle by township, 1997



Source: California Department of Food and Agriculture (CDFA), 2002e

Another example is cheat grass. Following its introduction in the late 1800s, it now dominates much of the western United States and the eastern slope of the Sierra Nevada mountains. This species, given its rapid maturation, short green period, and domination of disturbed sites has low value as a forage plant and reduces rangeland productivity. Cheatgrass in shrub/grass plant communities also provides a fuel source that increases fire hazard.

A third example is scotch broom. In coastal and foothill regions, it now covers more than 618,000 acres and has displaced native vegetation. This aggressive weed is of little value to wildlife. Roadways provide both the disturbance needed for establishment and corridors for dispersal. Scotch broom is expected to continue to expand its range with the increasing rate of rural development (Schwartz et al., 1996).

Findings on changing land uses

Change in land use provides a medium for the introduction, successful establishment, and expansion of non-native plant and animal species.

Change in land use is generally associated with alteration of ecological processes. As such, it provides a medium for the introduction, successful establishment, and expansion of non-native plant and animal species. Disturbance is a natural part of ecosystem function in many systems. However, society's large-scale alteration of the type and frequency of disturbances results in changed ecosystem states and increased opportunities for invasive species establishment, to the general detriment of native species (Hobbs, 2000).

The extent of the alteration and dominance of varying types of disturbance is determined by the prevalent land use. Each type of land use (e.g., conservation reserve, urban development, forest and range operations, or agricultural area) entails a specific set of direct and indirect impacts of varying severity on ecosystem function. As a consequence, there are, in general, a predictable set of interactions between changing patterns of land uses and the extent to which they modify the ecosystem and facilitate successful biological invasions (Hobbs, 2000).

Although relatively few species introduced to new environments successfully establish themselves or become serious threats, those that do can have a significant influence on ecological and economic conditions. Of the 1,045 non-native plant species that have become established in California, less than ten percent are classed as serious threats under current conditions (Randall and Hoshovsky, 2000; Randall et al., 1998). However, successfully established invasive species modify ecological processes, such as fire frequency and habitat value for rare species or compete with native species through a variety of mechanisms.

Medusa–head. Photo by Craig Thornsen, California Department of Food and Agriculture, Botany Laboratory.

Non-native species alteration of the disturbance regime under which native species have adapted is potentially the most damaging impact of the invading species on biological diversity and ecosystem function. An often-cited example is found in California's Great Basin and Eastern Sierra Nevada Mountains where cheatgrass (*Bromus tectorum*) dominated areas influence probability of fire occurrence, rate of spread, and intensity. This annual grass has contributed to widespread increases in fire frequency from once every 60-110 years to once every 3-5 years. As a result, native shrubs important to a variety of native wildlife have been eliminated or severely reduced in extent (Whisenant, 1990; Randall and Hoshovsky, 2000). In this case, the invading species initiates further system changes in terms of fire regime that perpetuate its existence and create conditions that facilitate increases in distribution (Whisenant, 1990).

Similar results have been noted in California's desert plant communities where introduced annual grass species have affected the frequency of wildfire and converted high diversity native desert scrub into low diversity introduced annual grassland. Probable negative effects from this conversion include reduced availability of preferred food plants, loss or reduction of available nutrients and trace elements, and change in the seasonal availability of plant foods (Brooks and Berry, 1999). Other researchers have noted the inability of desert adapted species, including some listed as threatened or endangered, to effectively forage or avoid predation in other than sparsely vegetated habitats (Germano et al., 2001).

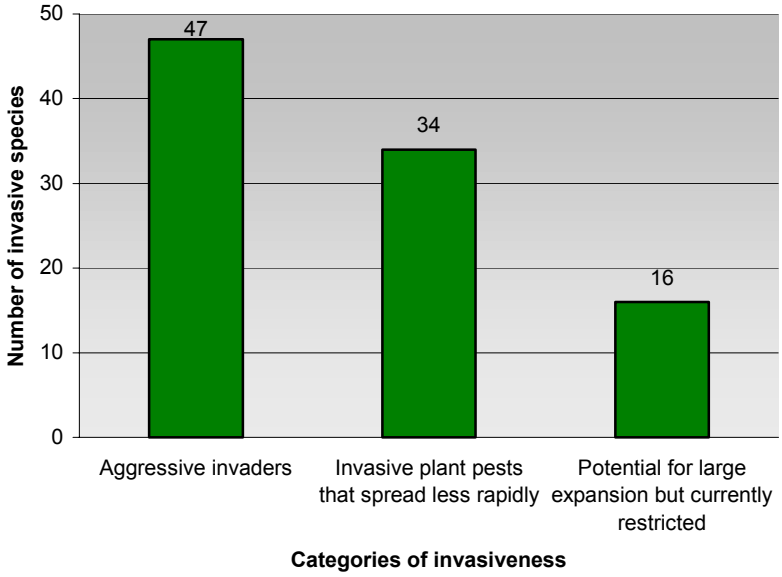
The successful establishment of an invasive species can also alter existing land uses or land use patterns and increase costs associated with the production of commodities or other values. Land values may be reduced such that alternative forms of land use are explored, or increased costs are experienced to maintain the existing land use through intensive management efforts (Hobbs, 2000).

Findings on exotic plant species

The introduction of exotic species can be serious threat to natural communities**.** Invasive non-native species alter ecosystem structure, composition, and processes and out-compete and exclude native plants and animals. The relatively few non-native species that have successfully established themselves in California's diverse environments have had far reaching effects. These effects include direct competition or hybridization with and subsequent exclusion of native species but also as an agent for the change of ecosystem function. These ecosystem effects include alteration of disturbance regimes such as frequency and intensity of fire, change in hydrologic cycles, and soil erosion rates.

Invasive plant species generally exhibit certain characteristics that make them effective competitors and which facilitate their establishment and dispersal. These include large numbers of easily dispersed seed, ability to reproduce by both seed and vegetative growth, and ability to persist under variable environmental conditions such as dry or wet soil conditions. Geographically separate biological regions now share an increasing number of species in common. Invading non-native species that are successful at establishing viable populations are generally symptomatic of landscapes and ecosystems that have been altered and have suffered a reduction in some of their original productive capacity. Figure 3 displays the number of invasive plant species identified in California and potential for expansion. Of particular concern is the large number of aggressive invasive species (Figure 3).

Figure 3. Statewide number of invasive plant species

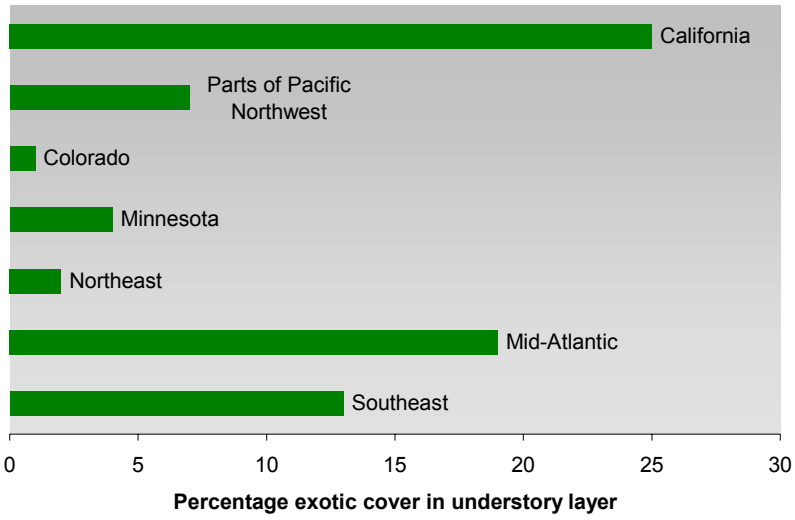


Source: California Exotic Pest Plant Council, 2002a, 2002b, and 2002c

Figure 4 shows the percentage of exotic plant cover in the understory layer for various U.S. regions. The graph is based on 1994 data from the Forest Health Monitoring Program, representing a full plant species inventory on 279 permanent plots in 18 states. Forest Health Monitoring is a partnership program between the U.S. Forest Service, state foresters, and others designed to assess trends in forest health annually.

This figure suggests two observations about non-native plants. First, California has the most extensive presence of exotic understory vegetation cover compared to other regions in the United States. Second, exotic plants cover a substantial portion (25 percent) of the State's understory vegetation signifying their abundance and potential threat.

Figure 4. Exotic plants in selected regions, 1994



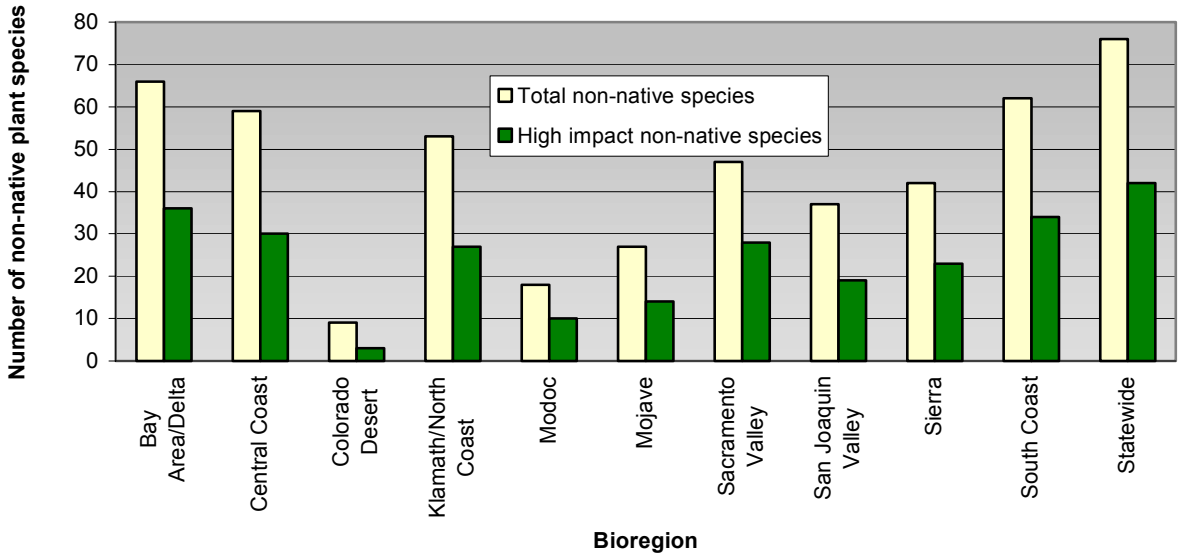
Source: Stapanian et al., 1998

A number of agencies and groups, including the California Exotic Pest Plant Council and the California Department of Food and Agriculture Noxious Weed Information Project maintain, lists of noxious weeds to help identify infestations and necessary management actions (see California Exotic Pest Plant Council and California Department of Food and Agriculture Noxious Weeds Information Project). These sources provided input into determining a set of "high impact" non-native invasive plant species (NIPS). High impact NIPS species are capable of having significant impacts on biological diversity, productive capacity, soil and water, and social well being. These impacts include out-competing native species, slowing timber regeneration and forage production, altering riparian shading and streambank morphology, and altering fire regimes affecting public heath and safety.

FRAP evaluated NIPS associated with forests and rangelands for their potential impacts on biological diversity values. The evaluation considered potential rate of spread, disruption to native species of concern, influences on ecological processes such as fire, and monotypical spread. Over all forests and rangelands statewide, 76 NIPS were identified as likely having some affect on biological diversity, with 42 classified as High Impact NIPS. Examples of high impact species to biological diversity values include cheat grass (*Bromus tectorum*), yellow star thistle (*Centaurea solstotoalis*), Scotch broom (*Cytisus scoparius*), and medusa-head (*Taeniatherum caput-medusae*). Other "high impact" non-native species and their rates of spread in California (Akers, 2001) are shown in the following maps (Figures 6-9).

An evaluation of the ocurrence and frequency of non-native invasive plants suggests they are prevalent throughout California, with the highest numbers of species occurring in the coastal bioregions. The South Coast and Bay Area/Delta bioregions (which already have high development pressures) also face a continued and severe threat to remaining biological diversity values from non-native plants (Figure 5).

Figure 5. Estimated number of non-native invasive plant species (NIPS) that impact biological diversity, by bioregion and statewide

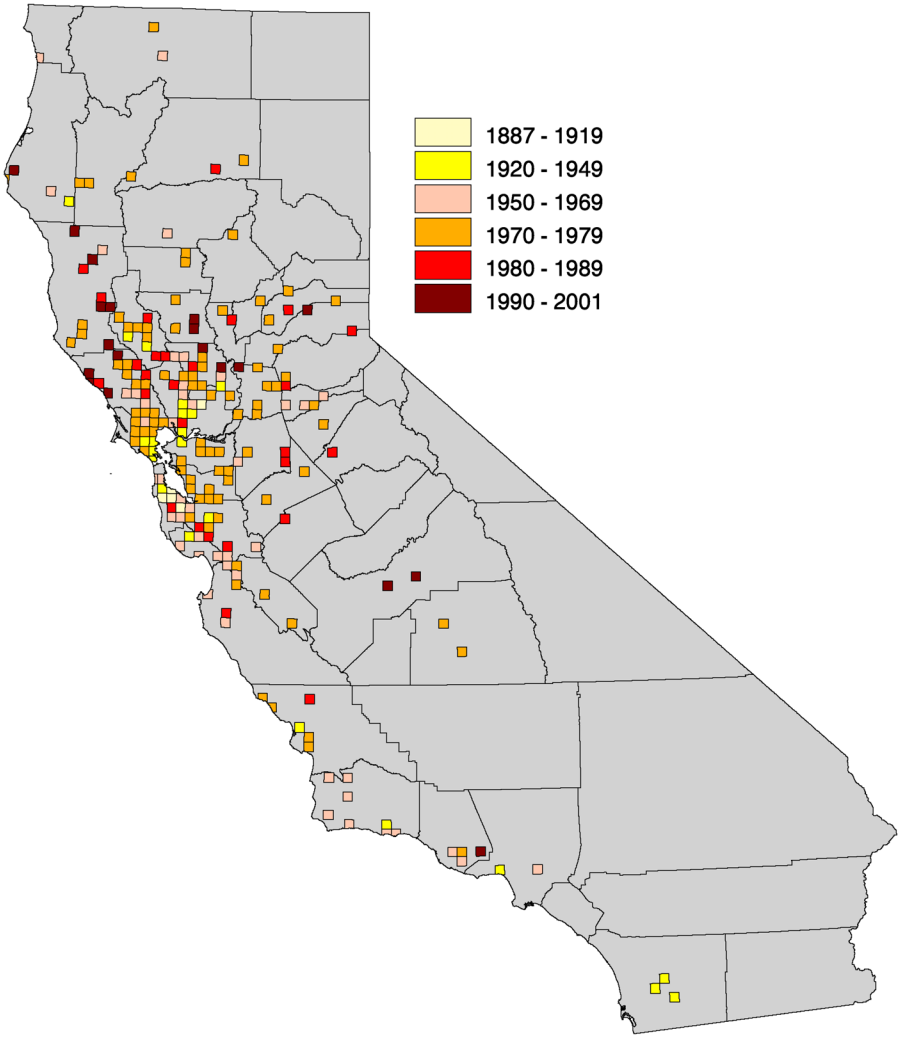


Source: Compiled by FRAP from Bossard et al., 2000;

Purple starthistle

Purple starthistle (*Centaurea calcitrapa*) (see California Exotic Pest Plant Council List B and California Department of Food and Agriculture Noxious Weed List) has been observed along coastal California from San Diego to Humboldt counties and in the Coast ranges and across the Central Valley to the Cascade and Sierra Nevada foothills (Figure 6). The species is considered particularly abundant in the vicinity of San Francisco Bay north to Marin, Solano, Napa, and Sonoma counties (Randall, 2000). This species, native to the Mediterranean of southern Europe and northern Africa, was first detected in California near Vacaville in 1886. It likely spread through the transport of agricultural products such as hay and straw or on farm machinery. This species replaces palatable rangeland species, and dense infestations make effective use of rangelands difficult.

Figure 6. Expansion of purple starthistle (1887-2001)



Source: CDFA, 2002c